Magnetic Forces in High-T_c Superconducting Bearings

F.C. Moon

Mechanical and Aerospace Engineering
Cornell University
Ithaca, New York 14853

In September 1987 researchers at Cornell levitated a small rotor on superconducting bearings at 10,000 RPM. In April 1989 a speed of 120,000 RPM was achieved in a passive bearing with no active control. The bearing material used was $YBa_2Cu_3O_7$. There is no evidence that the rotation speed has any significant effect on the lift force. We believe that the attainable rotation speeds in a vacuum will be over 300,000 RPM in the near future.

Magnetic force measurements between a permanent rare-earth magnet and high-T_c superconducting material versus vertical and lateral displacements have been made. A large hysteresis loop results for large displacements, while minor loops result for small displacements. These minor loops seem to give a slope proportional to the magnetic stiffness, and are probably indicative of flux pinning forces.

Experiments of rotary speed versus time show a linear decay in a vacuum. Measurements of magnetic drag forces of a magnetic dipole over a high-T_c superconducting disc of YBCO show that the drag force reaches a constant value, independent of the speed. Damping of lateral vibrations of levitated rotors have been measured which indicates that transverse flux motion in the superconductor will create dissipation.

As a result of these force measurements we have been able to design an optimum shape for the superconductor bearing pads which gives good lateral and axial stability. Recent force measurements on melt-quench processed superconductors indicate a substantial increase in levitation force and magnetic stiffness over free sintered materials. As a result, application of high-T_c supeconducting bearings are beginning to show great promise at this time.

F.C. Moon, M.M. Yanoviak, R. Ware, "Hysteretic Levitation Forces in Superconducting Ceramics," Appl. Phys. Lett., **52** (1988) 1534-1536.